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ABSTRACT

This curriculum guide contains eight units that provide the basic curriculum components required to develop lesson plans for the electrical occupations/residential electricity curriculum. The guide is not intended to be a complete, self-contained curriculum, but instead provides the teacher with a number of informational items related to the learning outcomes and allows the teacher flexibility to design instructional activities, select resources, and deliver instruction most appropriate for the learner and learning environment. The units of instruction contain the following components: learning outcomes; associated tasks; performance standards; lists of tools, equipment, resources, and limiting constraints; performance steps; and enabling objectives. The units cover the following topics: computer service loads; installing electrical environmental control components; installing lighting fixtures; installing service entrances; installing switch boxes and outlets; maintaining existing wiring; roughing in feeder, branch circuit cables, and circuits; and trimming out. A list of equipment to be carried in an electrical occupations/residential electricity tool kit completes the guide. (KC)

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VOCATIONAL EDUCATION CURRICULUM GUIDE

INDUSTRIAL AND TECHNICAL EDUCATION

ED279876

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ELECTRICAL OCCUPATIONS AND RESIDENTIAL ELECTRICITY

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ELECTRICAL OCCUPATIONS

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Preface

The concept of competency based vocational-technical education has been supported by the Bureau of Vocational, Technical and Adult Education for a number of years. Since the early 1970's, the State has sponored the development and dissemination of numerous competency based curricula through the State Vocational Curriculum Laboratory. With the recent development of the State Master Plan for Public Education, however, the need to move rapidly toward systemwide adoption of this instructional concept in all schools is mandated by State Board of Education Policy.

According to the State Master Plan for Public Education, all instructional programs are to be learner oriented and described in terms of high quality, measurable, student centered outcomes (learning outcomes). In essence, this policy reinforces the competency-based vocational education philosophy.

Consistent with our current efforts in encouraging the implementation of vocational education learning outcomes, we have prepared this curriculum guide to assist vocational teachers as they prepare lesson plans that are reflective of the mandated core curriculum and defensible in terms of an equitable, quality vocational program.

Additional copies of this curriculum guide may be obtained from the:

West Virginia Vocational Curriculum Laboratory
Cedar Lakes Conference Center
Ripley, West Virginia 25271
Telephone: (304) 372-7021
Toll Free: 1-800-WVA-JOBS (in state)

Any suggestions you have for improving this material may be sent to your Vocational Curriculum Laboratory. Through this feedback, we plan to continually update and revise our materials.

VOCATIONAL, TECHNICAL AND ADULT EDUCATION

Clarence E. Burdette
Assistant State Superintendent of Schools

Overview

The contents of this guide provide the basic curriculum components required to develop lesson plans that address the learning outcomes for this particular area of study. As such, this guide is not intended to be a complete, self-contained curriculum. Instead, the teacher is provided a number of informational items related to the learning outcomes and allowed the flexibility to design instructional activities, select resources and deliver instruction most appropriate for the learner and learning environment.

Specifically, this curriculum guide is organized in the following manner:

Units of Instruction (Where applicable)

A unit of instruction is a group or cluster of related learning outcomes that have been placed together for their similarity or main idea of task accomplishment. An example of a Unit would be Shielded Metal Arc Welding within the welding and cutting area of study.

Learning Outcomes

A learning outcome, oftentimes synomous with a competency statement, is a concise description of the curriculum in terms of desired learner behavior. Such statements are measurable, may contain one or more tasks and be action oriented. All approved learning outcomes for vocational education have undergone a strigent verification process with input from teachers and representatives of the business and/or industrial sector.

The approved learning outcomes for a specific vocational education area of study represent the core competencies of what has been identified as a quality vocational education experience. They do not, however, represent the entire instructional program for any area of study. It is hoped that all vocational instructors and local educational agencies will provide learners with educational experiences that exceed the "core competencies" identified through the learning outcomes.

Associated Tasks

A task represents an identifiable behavior that (1) has a purpose; (2) has a definite beginning and ending; (3) contains two or more steps none of which is a restatement of the original task statement if in the psychomotor domain; and (4) has a standard of performance which can be defined, described and verified. Learning outcome statements may be on the task level or may contain two or more independent tasks.

Examples of task/behavior statements are:

1. Chase external pipe threads.
2. Bleed diesel fuel system.
3. Use common standard medical abbreviations.
4. Prepare a resume.
5. Plan food experiences suitable for young children.

Performance Standards

The Standard is defined as criteria for assessing if tasks are performed or demonstrated as either acceptable or unacceptable. The performance standard communicates to the learner the quantity and quality of how well he or she is expected to complete the task. The standard can be stated in terms such as actual percentage of achievement, the accuracy expected, the number of errors permitted, the time allowed to complete the task, the degree, or any other appropriate level at which achievement is anticipated. The standard should be based on the performance level needed on the job.

Examples of standards are:

1. The circuit board must operate within the tolerances of the circuit design.
2. The estimate must be within + or -5% of that figured by the instructor.
3. Contacts must open when more than 125% of rated current value is made to pass through the overload relay heating element or coil.
4. The installation must be complete and each conductor must be terminated according to the schematic drawing of the design.
5. The motor must carry the load without being overloaded; the directions of rotation must be correct; belt must have a deflection of between 3/8" or 1/2".

Tools, Equipment, Resources and Situation(s)

Situation(s) is defined as the limiting constraints under which actions are to occur. The circumstances or restrictions imposed on the learner when he or she is demonstrating the behavior must be defined. Frequently, the conditions identify the testing situation used to determine learner achievement of the standard. Tools and equipment are the materials needed to perform the task being addressed in each performance standard.

Performance Steps

Performance steps are a series of steps required to perform a psychomotor task. The steps (1) are arranged in the sequence ordinarily followed on the job, (2) have a concise start and close, (3) are limited to the accompanying task statement, and

(4) are self-supporting and do not refer to actions beyond the task performance. Performance steps developed for each task are used to determine the enabling objectives and steps and procedures for performance checklist(s) to be utilized in assessing learner mastery of the task.

Enabling Objectives

Enabling objectives reflect the knowledges, attitudes and related skills the learner must possess in order to complete the task to the specified standard(s). As such, enabling objectives are derived from an instructional analysis of the task and/or performance steps and are stated in measurable terms of student performance.

Terms such as "define verbally," "construct," "diagram" and "list" are used to express enabling objectives, rather than obscure verbs like "know," "learn" and "understand". Examples of acceptable enabling objectives are:

1. List verbally the parts of a voltmeter.
2. Define Ohm's Law.
3. Explain relevant safety precautions and procedures.
4. Discriminate between types of life insurance policies.

Given this information for each outcome statement, the instructor is encouraged to develop the following components for lesson planning, delivery and evaluation.

Develop Instructional Activities

Instructional activities should be designed to provide the learner with experiences related to the enabling objectives, cumulating in successful task performance. The instructional activity section of a curriculum should contain a variety of strategies designed for the learners' varying learning styles and rates.

Consideration should be given to age, ability levels, educational levels, varied learning styles, individual interests, career goals, and emotional needs when developing the instructional activities. Activities should include suggestions for large groups, small groups and individual methods. The use of small groups may help students attain the skills, knowledge and attitudes associated with each task by making them (1) feel adequate and physically competent when they lack the necessary background information and experience; (2) feel a sense of security through the reenforcement of positive group attitudes; (3) gain confidence and discover that they are an essential part

of a team engaged in the learning-teaching process; (4) learn to work without direct supervision, and (5) vary instructional routines away from lecture or other full-class methods.

Identify Appropriate Instructional Resources

Instructional resources should be identified for each instructional activity and should be designed to help convey the message of the task and enabling objective(s). Attempts should be made to utilize modern instructional technology (i.e. television, computers, video-tapes, etc.) as much as possible in delivering the message desired. However, caution is advised in limiting the suggested resource section to only one alternative; due to the differing availability of resources between like programs across the state.

Provide Instruction

Many misconceptions exist about how an individual teacher must manage the instructional process when utilizing the competency based approach. Oftentimes CBE is considered synonmous with individualized instruction, wherein the instructor becomes the instructional manager of the educational process instead of the more traditional view of the teacher. Such misconceptions have led many educators to renounce competency based education as a means by which the teacher loses control and direction over the instructional process and is relegated to merely a role of record keeper.

The underlying concept of competency based instruction, however, does not dictate specific instructional procedures and methodologies, but rather assures that those skills, knowledges and attitudes deemed essential for job success are taught, mastered to acceptable standards and documented. How this instruction is managed within the classroom, be it on a large group, small group or individualized basis should be left up to the instructor.

The content of the task itself and the enabling objectives dictate what should be taught. Thus, the instructional activities and supporting resources identified in the instructional plan must be designed to accommodate learner mastery of the subject matter. Where appropriate, this instruction may involve large group activities, smaller group participation and/or solely individualized study.

Where substantial diversity exists between ability and skill levels of the learners within a class, arrangements should be made to structure learning activities that accommodate this difference. This type of instructional arrangement is particularly crucial, given that one of the major premises of competency based instruction is that the learner be allowed to progress at his/her own pace and that this progression be based upon successful mastery of sequential competencies.

Also, another major consideration that must be given to providing competency-based instruction is the development of a mechanism whereby learners, due to prior experience or instruction, be allowed to "test out" on skills already attained without undue duplication of effort. This situation is most often addressed through the use of pretests prior to formal instruction.

*Evaluate Learner Performance

Evaluation of learner performance is one of the most critical steps in the instructional process. Criterion-referenced evaluative measures are advocated over the traditional norm-referenced approach due to the importance of all learners being able to perform to specialized standards. As such, the evaluation of learning outcomes and their related tasks should include means of assessing learner mastery of the knowledges, attitudes, and skills outlined in the enabling objectives and regarded as essential for completion of the learning outcomes/tasks, and also, learner performance of the learning outcomes/tasks to the performance standard.

In order to adequately evaluate learners, consideration must be given to constructing testing situations that address any or all of the three domains of learning encompassed within the learning outcome or task (i.e., psychomotor, cognitive, and affective).

*Note: The Bureau of Vocational, Technical and Adult Education is currently in the process or has developed comprehensive test item banks (written and performance) for a number of vocational education areas of study. For information relative to the availability of these item banks, contact the Assistant Director, Curriculum and Personnel Development.

Guide Coding System

Example: 4.2.3

4. - unit designation
2. - learning outcome under unit
3 - task under learning outcome

VOCATIONAL EDUCATION CURRICULUM GUIDE

ELECTRICAL OCCUPATIONS/RESIDENTIAL ELECTRICITY

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PROGRAM OF STUDY: Industrial and Technical Education

AREA OF STUDY: Electrical Occupations/Residential Electricity

UNIT #1 Compute service loads

LEARNING OUTCOME # 1.1 Read and interpret electrical schematics and diagrams.

TASK # 1.1.1 Read and interpret electrical schematics and diagrams.

PERFORMANCE STANDARD: Identification of locations and types of outlets, special purpose outlets, fixtures, and load centers must be in accordance with schematics and diagrams. Identification of locations, types, sizes and wattage of lighting fixtures must be in accordance with schematics and diagrams. All identified outlets and fixtures must be in conformance with National Electrical Code and local code requirements.

TOOL, RESOURCES, EQUIPMENT AND SITUATION(S):

Local code book
National Electrical Code Book
Schematic/diagram/blueprints

PERFORMANCE STEPS:

1. Read floor plank and determine:
   a. Number and location of outlets.
   b. Number, type and location of switches.
   c. Number, type and location of lighting devices.
   d. Number, type and location of special circuits.
   e. Number and route of branch circuits.
   f. Size and location of panel boxes.
2. Calculate size of cable.
3. Calculate size of boxes.
4. Cross-reference calculations to National Electrical Code and local codes where necessary for minimum requirements.

ENABLING OBJECTIVES:

1. List and identify electrical symbols.
2. Explain the relevant sections of the National Electrical Code and the local code where applicable.
3. Explain how to calculate wattage.
4. Define the term balanced load.
5. Identify the overload protection requirements.
6. Identify the symbols for doors, windows, and passageways.

LEARNING OUTCOME # 1.2 Calculate individual circuit load.

TASK # 1.2.1 Calculate individual circuit load.

PERFORMANCE STANDARD: Circuit load must not total more than allowed overcurrent device ratings or current carrying capacity of conductors. Calculations of individual circuit load must meet requirements as outlined by National Electrical Code (Chapter 9, Example 1) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Floor plan
Local code manual
National Electrical Code
Unit data plate ratings

PERFORMANCE STEPS:

1. List of all possible equipment that is used at one time on individual circuit.
2. Determine wattage of all appliances being used or to be installed from manufacturer's data plate.
3. Total wattage on that line.
4. Divide total wattage by applied voltage to get total amperage for circuit load.
5. Allow 1 1/2 amps per outlet for light and convenience outlets not calculated as above.

ENABLING OBJECTIVES:

1. Explain the relevant sections of the National Electrical Code and local code.
2. Define the terms: amperage, voltage, wattage, load, and circuit.
3. Describe the function of ground fault interrupters and where they are required by code.
4. Identify wire sizes and their amperage ratings.
5. Differentiate between the National Electrical Electrical Code and the local code.
6. Explain how to interpret floor plans.

LEARNING OUTCOME # 1.3 Compute the size of service entrance conductors.

TASK # 1.3.1 Compute the size of service entrance conductors.

PERFORMANCE STANDARD: Total calculated load must include all circuits to be installed. Calculation of size of service entrance conductors must meet requirements as outlined by National Electrical Code (Article 220 and tables in Chapter 9) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Floor plans
Local code manual
National Electrical Code
Unit data plate rating

PERFORMANCE STEPS:

1. Calculate general lighting load.
2. Calculate number of branch circuits required and their load.
3. Calculate small appliance load.
4. Calculate laundry load.
5. Calculate total circuit load without major appliances.
6. Calculate circuit loads of major appliances

(range, central heat, and air conditioner).

7. Total all circuit wattage load for total wattage of house.
8. Divide total wattage by applied voltage to get total amperes.
9. Derate according to Chapter 9, National Electrical Code.
10. Use appropriate table from National Electrical to determine entrance cable size, after determining total amperes for load.

LEARNING OUTCOME # 1.4 Determine how many convenience and appliance outlets should be on each separate circuit.

TASK # 1.4.1 Determine how many convenience and appliance outlets should be on each separate circuit.

PERFORMANCE STANDARD # Number of circuits must be sufficient to supply load served. Number of convenience and appliance outlets must meet requirements as outlined by National Electrical Code (Article 220, Example 1, Chapter 9) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Floor plans
Local code manual
National Electrical Code

PERFORMANCE STEPS:

1. Allocate minimum number of appliance circuits according to National Electrical Code.
2. Choose each circuit and follow procedure below for determining number of receptacle outlets required:
   a. Determine individual branch circuit amperages.
   b. Take 80% of total branch circuit amperages.
   c. Divide answer in step b by 1.5 to determine number of outlets per circuit.

3. Identify required convenience/appliance outlets per circuit.
   NOTE: Refer to National Electrical Code Article 220-2c (5).

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of the National Electrical Code and local code.
3. Differentiate between local codes and the National Electrical Code.
4. Define the terms: circuit, load, receptacle, appliance outlet, and convenience outlet.
5. Explain how to calculate amperage draw from appliances.
6. Identify wire/cable sizes and their amperage capacity.

UNIT #2 Install electrical environmental control components.

LEARNING OUTCOME # 2.1 Use and maintain electrical test equipment.

TASK # 2.1.1 Use and maintain electrical test equipment.

PERFORMANCE STANDARD: Each meter must be attached into circuits with appropriate polarity. Instrument must be calibrated according to manufacturer's specifications. Reading must be + or - 10% of schematic requirements.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit	Manufacturer's manuals
Ammeter	Ohmmeter
Continuity meter	Voltmeter

PERFORMANCE STEPS:

FOLLOW EACH OF THESE STEPS FOR ALL METERS

1. Select appropriate scale setting.
2. Calibrate meter.
3. Attach probes to meter.
4. Wire probes into circuit.
5. Read meter scale.
6. Maintain meter according to manufacturer's suggested procedure.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Identify the function of these meters: volt, amp, ohm, and continuity.
3. Explain the difference between series and parallel configurations.
4. Explain meter calibration.
5. Explain direct read scales.
6. Explain multi-scale meter.
7. Explain multiplier ranges.
8. Explain meter sensitivity.

LEARNING OUTCOME #	2.2	Install baseboard heat unit and wall heater.
TASK(S) #	2.2.1	Install baseboard heat unit.
	2.2.2	Install wall heater.
TASK #	2.2.1	Install baseboard heat unit.
PERFORMANCE STANDARD:		Baseboard unit must be level. Baseboard must be installed without damage to unit or surrounding structures. Connection of baseboard heat units must meet requirements as outlined by National Electrical Code (Article 300 and 424) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit
Electric baseboard heat unit
Installation/electrical materials
Manufacturer's instruction manual
Roughed in wiring

PERFORMANCE STEPS:

1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Remove heat unit from housing, if required.
6. Attach wiring to housing.
7. Place temporary spacer approximately one inch thick under each end of heater to allow for later installation of floor covering.
8. Attach housing to wall.
   NOTE: Use a level to that unit is level.
9. Remove spacer.
10. Replace heat unit in housing, if unit was removed.
11. Identify conductors, make connections including equipment ground.
12. Check circuit to see if it is free of grounds using ohmmeter.
13. Install junction box cover and all trim hardware.
14. Turn power on.
15. Assure required current draw using ammeter.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of the National Electrical Code and local code.
3. Describe how a resistive heating system functions.
4. Identify the components of a baseboard electric heater.
5. Explain how to calculate wire size and amperage for baseboard heater.
6. Define the terms: line, neutral, and ground.
7. Describe how to operate a voltage tester.

TASK # 2.2.2 Install wall heater.

PERFORMANCE STANDARD: Connections must be made using approved connectors. Heater must be installed at specified location and must be grounded. Heater must provide heat equal to its capacity. Installation of the wall heater must meet requirements as outlined by National Electrical Code (Article 110, 300, and 310) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit	Manufacturer's instruction manual
Ammeter	
Electric wall heater	Roughed in wiring
Installation/ electrical materials	Voltage tester

PERFORMANCE STEPS:

1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Remove heating coils from housing.
6. Attach cable to housing.
7. Attach housing to structure.
8. Identify conductors.
9. Remove only sufficient insulation to accept connector.
10. Connect heater leads to power source.
11. Connect ground to grounding terminal.
12. Install heater in housing.
13. Install trim.
14. Turn power on.
15. Observe heater coils to see if they turn red.
16. Test heater performance with ammeter.
    a. Check connections if heater does not perform to specifications.
17. Assure required operation.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of the National Electrical Code and local code.
3. Describe how a resistive heating system functions.
4. Identify the components of a wall heater.
5. Explain how to calculate wire size and amperage for wall heater circuit.
6. Define the terms: line, neutralize, and ground.
7. Demonstrate how to operate voltage tester.

LEARNING OUTCOME #	2.3	Connect furnace motor, line, and low voltage thermostats.
TASK(S) #	2.3.1	Connect furnace motor.
	2.3.2	Connect line voltage thermostats.
	2.3.3	Connect low voltage thermostats.
TASK #	2.3.1	Connect furnace motor.

PERFORMANCE STANDARD: All connections must be tight and motor must be grounded. Connections must be in accordance with motor manufacturer's wiring diagram and materials. Furnace motor connections must meet requirements as outlined by National Electrical Code (Article 110) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

- Standard tool kit
- Ammeter
- Furnace motor
- Installation/ electrical materials
- Manufacturer's instruction manual
- Roughed in wiring
- Voltage tester

PERFORMANCE STEPS:

1. Locate installation point.
2. Turn power off.
3. Determine that power if off by checking conductor(s) at point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Identify conductors and determine connections for voltage supplied.
6. Attach power cable or conduit to motor controller.
7. Connect supply conductor to terminals provided on motor controller.
8. Run conduit, cable, or wire from motor controller to furnace motor.
9. Connect conductors at motor and at motor controller using approved connectors.
10. Install cover plates on junction boxes to cover exposed wiring.
11. Turn power on.
12. Turn motor controller on.
13. Check motor rotation.
14. Check motor amps with ammeter.
    NOTE: Amperage must be within limits set on motor data plate.
15. Assure required operation.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of the National Electrical Code and local code.
3. Identify the components controlling the operation of a furnace motor.
4. Define the terms: line, neutral, ground, load, and relay.
5. Demonstrate how to operate a voltage tester.
6. Differentiate between starting amperage and running amperage of a motor.
7. Demonstrate how to operate an ammeter.
8. Identify the styles of amperage measuring devices available.

TASK # 2.3.2 Connect line voltage thermostats.

PERFORMANCE STANDARD: Connections must be made using approved connectors. Thermostat must control unit it is attached to as evidenced by cycling on and off at its set point. Thermostat must have amperage rating equal to or higher than connecting load. Connections must meet requirements as outlined by National Electrical Code and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit	Manufacturer's installation instructions
Installation/ electrical material	National Electrical Code
Line voltage thermostat	Roughed in wiring

PERFORMANCE STEPS:

1. Locate installation point.
2. Turn power off.
3. Determine that power if off by checking conductor(s) at point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions
5. Attach supply cable or conduit to box for thermostat.
6. Identify conductors.
7. Connect load conductors to line terminals of thermostat.
8. Connect load conductors to load side of thermostat.
9. Attach thermostat to box provided for it.
10. Turn power on.
11. Set thermostat to desired temperature.
12. Observe operation through at least one cycle.
13. Assure required operation.
14. Turn power off or leave thermostat set for normal operation of equipment as per instruction of owner.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of the National Electrical Code and local code.
3. Identify the components in a line voltage thermostat.
4. Define the terms: polarity, line ground, neutral, and load.
5. Describe how to identify the load of a thermostat.

TASK # 2.3.3 Connect low voltage thermostats.

PERFORMANCE STANDARD: Connections must be made using methods and connectors suitable for conditions encountered. Thermostat must be mounted level and plumb. Heat anticipator adjustment must be set to match current rating of device being controlled. Connections must meet requirements as outlined by National Electrical Code and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit	Manufacturer's installation instructions
Installation/electrical materials	National Electrical Code
Local code	Roughed in wiring
Low voltage thermostat	Voltage tester

PERFORMANCE STEPS:

1. Locate installation point.
2. Turn power off.
3. Determine power is off by checking conductor(s) at point of connection(s) with voltage tester.
4. Remove thermostat from shipping carton.
5. Read manufacturer's installation instructions.
6. Remove approximately 3/4's inch insulation from each conductor.

7. Connect conductors to thermostat using methods and connectors suitable for conditions encountered, also observing color coding of wiring.
8. Attach thermostat to structure or designated point on equipment.
9. Determine that thermostat has been installed level and plumb.
10. Set heat anticipator adjustment to match current rating of device being controlled.
11. Install all trim and cover plates.
12. Turn power on
13. Assure required operation.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of the National Electrical Code and local code.
3. Identify the components of a low voltage thermostat system.
4. Differentiate between step-up and step-down transformers.
5. Identify the function of a relay and how it operates.
6. List the advantages of low voltage thermostat systems.

UNIT #3 Installing Lighting Fixtures

LEARNING OUTCOME # 3.1 Install fan controlled by a switch.

TASK # 3.1.1 Install fan controlled by a switch.

PERFORMANCE STANDARD: Connections must be made using methods and connectors suitable for conditions encountered. Connections must be tight. Switch must turn fan off when if off position and on when in on position. Installation of fan controlled by

switch must meet requirements as outlined by National Electrical Code (Articles 110, 300, and 310) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit	Manufacturer's installation instructions
Fan unit	National Electrical Code
Installation/electrical materials	Roughed in wiring
Local code	Switch
	Voltage tester

PERFORMANCE STEPS:

1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Remove approximately 3/4's inch insulation from each conductor.
6. Make wiring connections.
7. Fasten ground wire.
8. Attach fan to mounting brackets.
9. Turn power on.
10. Check fan for correct operation.
11. Assure required current drain.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of the National Electrical Code and local code.
3. Calculate the amperage draw of a fan.
4. Differentiate between starting and running amperage.
5. Define the terms: line, ground, and neutral.
6. Differentiate between the terms series circuit configuration and parallel circuit configuration.

LEARNING OUTCOME # 3.2 Install lighting dimmer system.

TASK # 3.2.1 Install lighting dimmer system.

PERFORMANCE STANDARD: Dimmer system must be installed at specified location and must operate within predetermined tolerances. Connections must be tight. Installation of a lighting dimmer system must meet requirements as outlined by National Electrical Code (Article 380) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit	Manufacturer's installation instructions
Installation/electrical materials	National Electrical Code
Light dimmer system	Roughed in wiring
Local code	Voltage tester

PERFORMANCE STEPS:

1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Examine dimmer to be sure it is appropriate type and size (fluorescent or incandescent).
6. Examine mounting boxes and circuit conductors to be sure they are in accordance with manufacturer's instructions.
7. Wire connections: circuit and grounding.
8. Install switches with mounting hardware.
9. Turn power on.
10. Assure required operation.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of the National Electrical Code and local code.
3. Identify the styles or types of dimmer control units available.
4. Describe how to calculate amperage for a given circuit component.
5. Differentiate between the terms fluorescent and incandescent.
6. List the advantages and disadvantages of fluorscent and incandescent fixtures.

LEARNING OUTCOME # 3.3 Install heat-a-vent light.

TASK # 3.3.1 Install heat-a-vent light.

PERFORMANCE STANDARD: Unit must be installed with clearance from frame work as recommended by manufacturer. All connections must be tight. Heat, vent, and light must be controlled by separate switches. Correct polarity must be maintained. Installation of heat-a-vent light must meet requirements as outlined by National Electrical Code (Article 110, 300, and 310) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATIONS:

Standard tool kit	Manufacturer's installation instructions
Heat-a-vent unit	National Electrical Code
Installation/electrical materials	Roughed in wiring
Local code	Voltage tester

PERFORMANCE STEPS:

1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Install housing per instructions.
6. Attach previously run wire from power source to housing using cable clamp and appropriate knock-out.
7. Remove approximately 3/4's inch of insulation from each conductor.
8. Identify all conductors.
9. Make all wiring connections observing polarity.
10. Connect ground wire.
11. Install cover plates on junction boxes to cover exposed wiring.
12. Install trim.
13. Turn power on.
14. Assure required operation.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of the National Electrical Code and local code.
3. Describe the function and operation of a heat-a-vent light.
4. Describe how to calculate wire size for heat-a-vent light.

LEARNING OUTCOME # 3.4 Install light fixture.

TASK # 3.4.1 Install light fixture.

PERFORMANCE STANDARD: Light must burn when switch is on. Fixture must cover hole and present a finished appearance. Correct polarity must be maintained. Installation of the light fixture must meet requirements as outlined by National Electrical Code (Article 110, 300, 310, and 410) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATIONS:

Standard tool kit	Manufacturer's installation instructions
Installation/electric materials	National Electrical Code
Light fixture	Roughed in wiring
Local code	Voltage tester

PERFORMANCE STEPS:

1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Connect fixture wire to power supply observing polarity.
6. Connect ground wire.

7. Attach fixture base to box with screws supplied.
8. Install lamps.
9. Turn power on.
10. Assure required operation.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of the National Electrical Code and local code.
3. Explain how a voltage tester operates.
4. Identify types of voltage testers available.
5. Describe color code system for wires in residential and commercial electricity.
6. Identify the parts of a light socket.
7. Explain the wiring requirements for a light socket as per the National Electrical Code.

LEARNING OUTCOME # 3.5 Install photo-electric control on light.

TASK # 3.5.1 Install photo-electric control on light.

PERFORMANCE STANDARD: Light must turn on at dusk and turn off at dawn or when conditions are simulated. Installation of photo-electric control on light must meet requirements as outlined by National Electrical Code (Article 410) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATIONS:

Standard tool kit	National Electrical Code
Light fixture	Photo-electric control
Local code	Roughed in wiring
Manufacturer's installation instructions	Voltage tester

PERFORMANCE STEPS:

1. Locate light to receive photo-electric control.
2. Turn power off.

3. Determine that power if off by checking conductor(s) at point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Remove light.
6. Check light for knockout that will accept photo cell.
   a. If none exists, use drill or other means to make desired hole.
7. Attach photo-electric control to light base.
8. Connect wire ends per manufacturer's installation instructions.
9. Hang light.
10. Turn power on.
11. Test according to manufacturer's installation instructions.
12. Test as follows if instructions are not supplied:
    a. Place dark covering over cell lens. Light should come on in approximately three minutes.
    b. Remove dark covering. Light should stop burning in approximately three minutes.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of the National Electrical Code and local code.
3. Describe the components of a photo-electric control system.
4. Explain how a photo-electric control system operates.
5. Explain how to strip conductors.
6. Identify techniques for connecting cables to each other and terminals.

LEARNING OUTCOME # 3.6 Install power failure lighting.

TASK # 3.6.1 Install power failure lighting.

PERFORMANCE STANDARD: Power failure light must be located to give maximum light when activated. All connections must be tight. Light fixture must be

securely fastened to structure and must turn on when power has been disrupted. Installation of power failure lighting must meet requirements as outlined by National Electrical Code (Article 700) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATIONS:

Standard tool kit	National Electrical Code
Installation/electrical materials	Power failure lighting device
Local code	Roughed in wiring
Manufacturer's installation instructions	Voltage tester

PERFORMANCE STEPS:

1. Locate installation point.
2. Turn power off.
3. Determine that power if off by checking conductor(s) at point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Attach power failure light to structure per manufacturer's instructions.
6. Fasten branch circuit, cable or conduit to light.
7. Remove approximately 3/4's inch insulation from each conductor.
8. Make all electrical connections observing polarity.
9. Install all cover plates on junction boxes to cover exposed wiring.
10. Turn power on.
11. Wait for time sufficient to charge batteries.
12. Push test switch.
13. Turn power off.
14. Assure required operation.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of the National Electrical Code and local code.
3. Identify the types of equipment that can be used to test voltage.
4. Identify the components of a power failure lighting unit.

5. Describe how a power failure light system functions.
6. Identify types of batteries for power failure systems.
7. Differentiate between AC and DC power.

LEARNING OUTCOME # 3.7 Install an appliance pilot light.

TASK # 3.7.1 Install an appliance pilot light.

PERFORMANCE STANDARD: Pilot light must be installed where it will be readily visible and must burn only when unit or appliance is in operation. Installation must meet National Electrical Code and local code requirements.

TOOLS, RESOURCES, EQUIPMENT AND SITUATIONS:

Standard tool kit	Manufacturer's installation instructions
Equipment to receive pilot light	National Electrical Code
Installation/electrical material	Pilot light
Local code	Roughed in wiring
	Voltage tester

PERFORMANCE STEPS:

1. Locate appliance or equipment to receive pilot light.
2. Locate installation point of pilot light.
3. Turn power off.
4. Determine that power is off by checking conductor(s) at point of connection(s) with voltage tester.
5. Read manufacturer's installation instructions.
6. Attach pilot light to appliance or equipment.
7. Run wire of correct size from load side of equipment terminals to pilot light.
8. Connect wire ends of pilot light to wires run from load terminals.
9. Turn power on.
10. Assure required operation.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of the National Electrical Code and local code.
3. Identify the function and purpose of a pilot light system.
4. Differentiate between series and parallel circuit configuration.
5. Describe how to calculate wire size for the equipment being serviced and the pilot light.
6. Identify the sections of the National Electrical Code that might apply to a particular installation.

UNIT #4 Install Service Entrance

LEARNING OUTCOME # 4.1 Ground service entrance equipment.

TASK # 4.1.1 Ground service entrance equipment.

PERFORMANCE STANDARD: Connections must be made at designated points and must be tight. Grounding of service entrance equipment must meet requirements as outlined by National Electrical Code (Article 250, Parts G, H, J, and K) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATIONS:

Standard tool kit	Installation/electrical material
Clamp	
Corrosive inhibitor	Local code
Ground service entrance equipment	National Electrical Code

PERFORMANCE STEPS:

1. Remove meter base cover.
2. Locate all installation points.

3. Apply corrosive inhibitor if required by authority having jurisdiction.
4. Terminate grounding conductor at point designated by authority having jurisdiction.
5. Drive ground rod or bury grounding electrode.
6. Fasten ground wire to grounding electrode with clamp approved for direct burial.
7. Attach wire to surface of structure.
8. Extend grounding conductor to water pipe if metal water system is installed.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of the National Electrical Code and local code.
3. Identify the function purpose of grounding the service entrance equipment.
4. Describe the function or operation of the service entrance.
5. Describe how to calculate the cable size required for service entrance grounding.
6. Explain when it is not necessary to drive grounding rod into the ground.
7. Identify types of clamps permitted n grounding rods.
8. List the types of rods permitted to be used for grounding.

LEARNING OUTCOME # 4.2 Install main service panel and circuit breakers.

TASK # 4.2.1 Install main service panel and circuit break

PERFORMANCE STANDARD: Main service panel and circuit breakers must meet requirements outlined in National Electrical Code (Article 110, 230, 240, and 384). Panel must be securely attached and plumb to structure. Breakers must fully engage busses and not exceed amperage of conductors.

TOOLS, RESOURCES, EQUIPMENT AND SITUATIONS:

Standard tool kit	National Electrical Code
Circuit breakers	Service panel
Local code	VOM

PERFORMANCE STEPS:

1. Locate main service panel as close to point of service entrance as possible.
2. Locate height of main disconnecting means from floor level as required by electrical code(s).
3. Remove knockout from main service panel.
4. Mark hole for raceway.
5. Cut hole through storm sheathing 1/2" larger than circle drawn for knockout.
6. Install raceway from point of entrance to main service panel.
7. Attach service panel to structure.
8. Check breaker size and type to ensure that breaker is suitable for use in panel.
9. Insert breakers in breaker box.
   NOTE: Pay attention to obtain equal load distribution.
10. Assure continuity with VOM.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain panel location restrictions of the National Electrical Code and local code where applicable.
3. Explain use of VOM.
4. List the gage of wire used for 15 amp and 20 amp breakers.
5. Explain the function of circuit breakers.
6. State the differences and advantages of a circuit breaker system over a fuse type system.

LEARNING OUTCOME # 4.3 Install mast-type service entrance.

TASK # 4.3.1 Install mast-type service entrance.

PERFORMANCE STANDARD: All work must be done in manner to prevent water from entering system. Service mast must also be able to

support service drop. Roof clearances, size and type of conduit must meet requirements of National Electrical Code (Article 230, Part C and Article 310) and local authority having jurisdiction. Service entrance conductors must not be shorted or grounded and be size and type as specified.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit	Roof flange
Fittings	Safety equipment
Local code	Waterproof sealant
National Electrical Code	Weatherproof weatherhead

PERFORMANCE STEPS:

1. Request power supplier to spot meter base.
2. Construct vertical line to roof overhang from meter base.
3. Locate center of hole on soffit board.
4. Bore hole slightly larger than conduit through soffit board, decking, and roofing.
5. Install conduit through roof down to meter base.
6. Tighten conduit into hub of meter base.
7. Fasten conduit to wall with rigid conduit straps.
8. Install roof flange around conduit, secure to roof.
9. Run service entrance conductors down to meter base.
   NOTE: Leave enough of free conductor from top of conduit to meet local requirements.
10. Connect service entrance conductors to line lugs of meter base and tighten securely.
11. Run conductors from load lugs of meter base to disconnect in main service panel.
12. Install weatherhead with one wire per hole in weatherhead.
13. Seal with waterproof sealant where conduit enters soffit board.
14. Test service entrance conductors for shorts or grounds.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of the National

Electrical Code and local code.

3. Describe how to calculate the conductor size of entrance cable.
4. Identify the parts of the weatherhead.
5. Define the term drip loops.
6. Define the terms: short, open, and grounded.
7. Demonstrate how to apply waterproof sealant.

LEARNING OUTCOME # 4.4 Install main service disconnect.

TASK # 4.4.1 Install main service disconnect.

PERFORMANCE STANDARD: Main service disconnect must be installed so that it simultaneously disconnects all ungrounded service entrance conductors. Main service disconnect must be qualified for use in service entrance and must be of specified amperage. Service disconnect must meet requirements as outlined by National Electrical Code (Article 230, Part H, and Article 110 and 250) and local codes where applicable.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit	Main disconnect unit
Cables	National Electrical Code
Local codes	Roughed in wiring

PERFORMANCE STEPS:

1. Locate installation point for main service disconnect.
2. Attach main service disconnect to building structure.
3. Attach feed cables into main service disconnect.
4. Connect service conductors to line lugs of disconnect.
5. Connect load conductors to load lugs of disconnect.
6. Terminate load conductors at load being serviced.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Outline the requirements as set forth in the National Electrical Code and local code.
3. Explain how a main disconnect unit functions.
4. Explain how to calculate the proper amperage requirement.
5. Explain the difference between line lugs and load lugs.
6. Describe the location requirements for the main disconnect.

UNIT #5 Install Switch Boxes and Outlets

LEARNING OUTCOME # 5.1 Install bar-hanger mounted box.

TASK# 5.1.1 Install bar-hanger mounted box.

PERFORMANCE STANDARD: Box must be securely mounted and must be flush with finished ceiling. Box must be located according to plans. Installation must meet requirements as outlined by National Electrical Code (Article 370) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit
Bar hanger
Electrical box
Fasteners
Floor plans
Local codes
National Electrical Code

PERFORMANCE STEPS:

1. Locate installation point.
2. Break out appropriate holes for number of cables entering box.
3. Attach bar to joist so that box will be flush with finished ceiling.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Outline the requirements set forth by the National Electrical Code.
3. Explain the methods of fastening the mount system.
4. Demonstrate ability to read floor plans to determine location for mounting unit.
5. Explain the conditions for determining the size of the box.
6. Determine from the floor plan the type of ceiling so you can obtain a flush mount position.

LEARNING OUTCOME: 5.2 Install flush mount junction box and surface mount junction boxes.

TASK # 5.2.1 Install flush mount junction box and surface mount junction boxes.

PERFORMANCE STANDARD: Box must be located according to plans. Junction box must be accessible after installation. Box must be securely mounted to structure. Installation must meet requirements as outlined by National Electrical Code (Article 370, Part B) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit	Junction box
Fasteners	Local code
Floor plans	National Electrical Code

PERFORMANCE STEPS:

1. Locate installation point.
2. Position junction box so it is accessible.
   NOTE: Junction box should be flush with face or back.
3. Attach junction box to structure so that it will be in accordance with floor plan.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Outline the requirements set forth by the National Electrical Code.
3. Explain how to read floor plans to determine the location and method of mounting.
4. Explain how to determine the size of the junction box.
5. Discuss the differences between a flush mount and a surface mount.
6. Explain the conditions where you can use a surface mount and where you need a flush mount junction box.
7. Explain why junction boxes are used.

LEARNING OUTCOME #	5.3	Install flush mount switch and outlet box in a drywall, lath or plastic, or paneled wall.
TASK #	5.3.1	Install flush mount switch and outlet box in a drywall, lath or plastic, or paneled wall.
PERFORMANCE STANDARD:		Switch box and/or outlet box must comply with governing codes, must be mounted securely and flush with finished surface and must be located according to plans. Installation type and location of switch box and outlet box must meet requirements as outlined by National Electrical Code (Article 370, Part B) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit	Floor plans
Boxes	Local code
Fasteners	National Electrical Code

PERFORMANCE STEPS:

1. Locate installation point.
2. Determine thickness of finished surface.
3. Break out appropriate holes for cables entering box.
4. Position switch box and/or outlet box.
5. Attach to structure so that box will be flush with finished surface.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain relevant National Electrical Code Requirements.
3. Demonstrate various fastening techniques.
4. Explain height requirements for switch boxes.
5. Discuss box size considerations.
6. Explain how to read floor plans to determine thickness of finishing material to obtain flush mount.
7. Explain why a box must be securely attached to the structure.
8. Explain how to read floor plan to obtain location point.

LEARNING OUTCOME # 5.4 Install gangable outlet boxes.

TASK # 5.4.1 Install gangable outlet boxes.

PERFORMANCE STANDARD: Gangable boxes must be of required size and type. Boxes must be fastened securely to structure and must be level across top. Installation of boxes must meet requirements as outlined by National Electrical Code (Article 370, Part B) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit	Gangable boxes
Fasteners	Local code
Floor plans	National Electrical Code

PERFORMANCE STEPS:

1. Locate installation point.
2. Determine number of boxes needed.
3. Break out appropriate holes for cables entering box.
4. Fasten boxes together.
5. Attach boxes to structure as to be flush with finished surface.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the National Electrical Code Requirements.
3. Demonstrate fastening techniques.
4. Explain the height requirements for switch and outlet location.
5. Explain advantages of gangable boxes.
6. Calculate box sizes.
7. Explain the limitations of gangable boxes.

LEARNING OUTCOME # 5.5 Install octagon outlet box.

TASK # 5.5.1 Install octagon outlet box.

PERFORMANCE STANDARD: Outlet box must be mounted securely to structure and be located according to plan. Installation and location of octagon outlet boxes must meet requirements as outlined by National Electrical Code (Article 370, Part B) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit	Octagon box
Fasteners	Local code requirements
Floor plans	National Electrical Code

PERFORMANCE STEPS:

1. Locate installation point on structure.
2. Break out appropriate holes for cables entering box.
3. Attach octagon outlet box to structure according to electrical plans.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the National Electrical Code requirements.
3. Demonstrate fastening techniques.
4. Explain how to read floor plan to determine the location of octagon outlet box.
5. Calculate box size.
6. Explain why and where octagon boxes are used.
7. Explain the limitations of octagon boxes.

LEARNING OUTCOME # 5.6 Install outlet boxes for receptacles and switches in existing wall.

TASK # 5.6.1 Install outlet boxes for receptacles and switches in existing wall.

PERFORMANCE STANDARD: Installed receptacles and/or switch boxes in existing wall must be of required size and type. Boxes must be located as specified in floor plans and must be level across top. Installation of fixture housing must meet requirements as outlined by National Electrical Code (Article 370, Part B) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit	Local code
Boxes	National Electrical Code
Floor plans	Roughed in wiring

PERFORMANCE STEPS:

1. Locate installation point.
2. Draw outline of box on wall near stud, if possible.
3. Cut holes in existing wall of size to accept box to be installed or remove paneling or wall board.
4. Break out appropriate holes for cables entering box.
5. Attach and level box to structure.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the requirements outlined by the National Electrical Code.
3. Explain techniques for locating wall studs.
4. Explain box size calculations.
5. Demonstrate techniques to secure box to structure.

LEARNING OUTCOME # 5.7 Install recessed fixture housing in ceiling.

TASK # 5.7.1 Install recessed fixture housing in ceiling.

PERFORMANCE STANDARD: Box must be mounted in correct location and must be strong enough to support fixture. Fixture must be controlled by switch or other means. Fixture must be installed according to manufacturer's recommended clearances. Installation of recess fixture housing must meet requirements as outlined by National Electrical Code (Article

410, Part B, and 410-8) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit	National Electrical Code
Floor plans	Recessed fixture housing
Local code	Roughed in wiring
Manufacturer's instructions	

PERFORMANCE STEPS:

1. Locate installation point.
2. Measure clearances to meet manufacturer's recommendations.
3. Cut holes of correct size in ceiling at desired location.
4. Break out appropriate holes for cable entering box.
5. Attach fixture housing to structure per manufacturer's instructions.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the National Electrical Code requirements.
3. Explain clearance requirements.
4. Demonstrate fastening techniques.
5. Explain how to read floor plan to determine location of fixtures.
6. Explain the necessity of clearances.

UNIT #6 Maintain Existing Wiring

LEARNING OUTCOME # 6.1 Diagnose and repair fluorescent fixtures.

TASK # 6.1.1 Diagnose and repair fluorescent fixtures.

PERFORMANCE STANDARD: Defective parts must be replaced with working equivalent parts. Light must turn on when repairs are complete.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit
Fluorescent fixture
Repair part
Voltmeter

PERFORMANCE STEPS:

1. Check voltage with voltmeter.
2. Check visually for darkened ends, burning red at ends, or flashing on and off.
   NOTE: Make sure that proper voltage is applied and power is on.
   a. Replace bulb if any of these conditions exist and proceed to step 9.
3. Determine if fixture is self-starting or uses separate starters if bulbs are not defective.
4. Replace with new starters of correct size.
5. Turn power off if bulbs and starters are not defective.
6. Remove cover from fixture.
7. Check wiring inside fixture for loose connections.
   a. Replace ballast, if wiring is not loose and bulbs and starters are not defective.
8. Re-install cover and other parts removed for wiring inspection.
9. Turn power on.
10. Assure fluorescent light operation.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain danger involved with fluorescent tube breakage.
3. Demonstrate how to attach and read voltmeter.
4. Explain how a ballast functions.
5. Explain how a starter functions.
6. Explain the advantage and disadvantages of fluorescent fixtures.

LEARNING OUTCOME # 6.2 Diagnose and repair and replace lights.

TASK # 6.2.1 Diagnose and repair and replace lights.

PERFORMANCE STANDARD: Parts must be replaced with approved working equivalent parts. Light must burn when repairs are complete.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit
Ohmmeter
Replacement part
Voltmeter

PERFORMANCE STEPS:

1. Remove and test bulb with ohmmeter or other means.
2. Check fixture voltage if bulb is good for correct voltage at light fixture connections.
   a. If voltage is correct in fixture feed connections, fixture must be repaired or replaced.
      a. Turn power off.
      b. Remove fixture.
      c. Repair or replace fixture.
      d. Re-install fixture.
   b. If voltage is incorrect, check/correct for problems at power supply.
      a. Measure continuity of fuse(s)/breaker(s).
      b. Remove/replace faulty fuse(s)/breaker(s).
3. Replace bulb.
4. Return light to service.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Demonstrate how to connect and read an ohmmeter.
3. Explain how to use a neon tester.
4. List possible causes for wiring connections to become non-functional.
5. Explain fuse and circuit breaker testing.

LEARNING OUTCOME # 6.3 Troubleshoot timer and change elements in a water heater.

TASK # 6.3.1 Troubleshoot timer and change elements in a water heater.

PERFORMANCE STANDARD: All replacements must be made with equivalent parts. Water heater must be equipped with pressure relief valve. When repairs are completed, water heater must heat at rated capacity and to temperature of thermostat setting.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit	Ohmmeter
Amprobe	Voltage tester
Manufacturer's instructions	Water heater element

PERFORMANCE STEPS:

1. Turn power off.
2. Remove access panel from water heater.
3. Inspect wiring and terminal connections.
4. Turn power on.
   CAUTION: ENSURE THAT WIRING IS SECURE AND ROUTED AS REQUIRED
5. Check for correct voltage at line terminals on high limit control.
   a. Check power supply if voltage is not correct.
6. Check voltage at load terminals.
   a. Press reset button on high limit control if there is no voltage at load terminals.
   b. Replace high limit control if power is not restored.
7. Check voltage at load terminals on thermostat.
   a. Replace thermostat if correct voltage is not present.
8. Turn power off.
9. Check heating element(s), using ohmmeter, for open shorts and grounds.
10. Turn off water supply, drain tank and replace element if element(s) must be replaced.
11. Determine if pressure relief valve is in place.
12. Turn water supply on and open hot water faucet to let air escape while tank is filling.
    NOTE: Element must be in place for this step.

13. Turn faucet off when tank is full.
14. Check for leaks.
15. Turn power on.
16. Assure required operation with amprobe.
17. Replace access panel.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain how to connect and read the scales on the voltmeter.
3. Explain how a hot water heater functions.
4. Explain the function of a high limit control.
5. Explain the operation of a reset switch.
6. Explain the operation of a thermostat.
7. Demonstrate how to test a heating element.

LEARNING OUTCOME # 6.4 Replace circuit breakers, fuses, and cable.

TASK(S) #
- 6.4.1 Replace circuit breakers.
- 6.4.2 Replace fuses.
- 6.4.3 Replace cables.

TASK # 6.4.1 Replace circuit breakers.

PERFORMANCE STANDARD: Breakers must be identified for use with panel, must be of required size and type, and must be fully inserted to engage with the busses.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit
Circuit breakers
Volt tester

PERFORMANCE STEPS:

1. Turn power off.
2. Determine that power if off by checking conductor(s) at point of connection(s) with voltage tester.
3. Remove one breaker from panel.
4. Remove conductor from old breaker.

5. Connect new breaker to conductor.
6. Install breaker to panel.
7. Replace each breaker in the same manner.
8. Turn power on.
9. Assure required operation.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain relevant sections of the National Electrical Code.
3. Explain function of circuit breaker and how it operates.
4. Explain ratings of circuit breakers and their relationship to cable/wire capacity.
5. Explain the effect of not engaging the breaker fully into the busses.

TASK # 6.4.2 Replace fuses.

PERFORMANCE STANDARD: Fuses must meet requirements as outlined by National Electrical Code (Article 240, Part E) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit
Assorted fuses
Local code
National Electrical Code
Voltage tester

PERFORMANCE STEPS:

1. Turn power off serving fuse panel.
2. Remove cover from fuse panel so wire size can be observed if there is a question as to fuse size.
3. Check wiring connections.
4. Insert all fuses of correct size and type. Be sure all fuses are tight in holders.
5. Turn power on.
6. Check voltage with tester at each fuse holder.
7. Replace fuse panel cover.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain relevant section of the National Electrical Code.

3. Explain fuse sizes and their relationship to cable and wire size.
4. Demonstrate connecting and reading a voltage tester.
5. Explain different types of fuses and their applications.
6. Explain removal and replacement of cartridge and blade type fuses.

TASK # 6.4.3 Replace cables.

PERFORMANCE STANDARD: Replaced cable must meet requirements as outlined by National Electrical Code (Article 300, Part A, and Article 200) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit
Cable
Local code
National Electrical Code
Voltage tester

PERFORMANCE STEPS:

1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at point of connection(s) with voltage tester.
4. Remove old cable being replaced.
5. Terminate cable inside enclosure through approved connectors.
6. Connect cable to terminals or splice to other conductors with approved splices. Connections must be tight and polarity correct.
7. Tape or otherwise insulate connections to withstand applied voltage where required.
8. Turn power on.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of the National Electrical Code.
3. Explain load calculations for cable size.
4. Explain wire and cable sizing.
5. List types of connectors and explain their use.
6. Explain wire length protrusion from box.

LEARNING OUTCOME # 6.5 Replace existing receptacle, switch and transformer.

TASK(S) # 6.5.1 Replace existing receptacle and switch.

6.5.2 Replace existing transformer.

TASK # 6.5.1 Replace existing receptacle and switch.

PERFORMANCE STANDARD: Switch and/or receptacle must be replaced with one of same type and voltage rating as original. Switch and/or receptacle must be mounted in same position as original and covers in place, straight, and plumb. Installation of switch and/or receptacle must meet requirements as outlined by National Electrical Code (Article 210) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit
Local code
National Electrical Code
Receptacles
Switches

PERFORMANCE STEPS:

1. Turn power off.
2. Determine that power is off by checking conductor(s) at point of connection(s) with voltage tester.
3. Remove switch or receptacle from box.
4. Disconnect conductor from existing receptacle and switch.
5. Connect switch or receptacle observing correct polarities.
6. Connect ground wire to grounding terminal on receptacle.
7. Push switch or receptacle into outlet box and tighten screws.
8. Replace outlet covers.
9. Turn power on.
10. Check for proper polarity.
11. Turn switch on.
12. Assure receptacle/switch operation.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of the National Electrical Code.
3. Explain amperage and voltage ratings of switches and outlets.
4. Demonstrate connecting and reading voltage testers.
5. Explain polarity of receptacles and switches.
6. Explain the wiring variations for single pole, three-way switches, and four-way switches.

TASK # 6.5.2 Replace existing transformer.

PERFORMANCE STANDARD: Transformer must match or exceed rating of original transformer.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit
Transformer

PERFORMANCE STEPS:

1. Locate existing transformer.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at point of connection(s) with voltage tester.
4. Remove existing transformer.
5. Read manufacturer's instructions for replacement transformer.
6. Attach transformer to device.
7. Remove cover plates.
8. Make necessary wiring connections, using appropriate connectors.
9. Replace all cover plates.
10. Turn power on.
11. Assure required operation of transformer.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain transformer action.
3. Explain the problems that could occur if the transformer were wired in reverse.
4. Explain connecting and reading voltage tester.

5. Explain transformer polarity.
6. Explain testing of a transformer for continuity.
7. Explain transformer construction.
8. Describe the winding configuration of a transformer.
9. Differentiate between step-up and step-down transformers.
10. Define the term ballast.

LEARNING OUTCOME # 6.6 Test for correct voltage.

TASK # 6.6.1 Test for correct voltage.

PERFORMANCE STANDARD: Voltage must be equal to unit data plate requirements or must be same as supplied by power distributor for given circuit.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit
Test circuit
Voltmeter

PERFORMANCE STEPS:

1. Locate circuit to be tested.
2. Determine what voltage should be.
3. Turn circuit on at distribution service panel or switch.
4. Check voltage using voltmeter.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. List and identify the components of a voltmeter.
3. Demonstrate proper use of voltmeter.
4. Explain scales found on a voltmeter.
5. Read and interpret scales on a voltmeter.
6. Explain the principles of a circuit.

LEARNING OUTCOME # 6.7 Troubleshoot a branch circuit.

TASK # 6.7.1 Troubleshoot a branch circuit.

PERFORMANCE STANDARD: Circuit must be checked for open circuits, short circuits, correct voltage, and correct polarity. All connections must be tight. Voltage must be as required and circuit must function.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit
Branch circuit
Voltmeter

PERFORMANCE STEPS:

1. Turn power off, if required.
2. Locate power source and route of circuit to be checked.
3. Remove all cover plates.
4. Check all connections.
5. Check voltage with voltmeter at each outlet beginning at service panel.
6. Check each outlet for correct polarity.
7. Inspect for short, open, or faulty circuit(s) using ohmmeter.
   a. Repair or replace circuit(s).
8. Replace all protective covers.
9. Turn power on.
10. Assure required operation.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Demonstrate how to test for an open circuit.
3. Explain what an open circuit is.
4. Demonstrate how to test for a short circuit.
5. Explain what a short circuit is and what can cause a short circuit.
6. Explain the dangers involved with a short circuit.
7. Explain how to check polarity.
8. Explain how to read a voltmeter.
9. Explain how to connect a voltmeter.

UNIT #7 Rough in Feeder, Branch Circuit Cables, and Circuits.

LEARNING OUTCOME # 7.1 Rough in 120 or 240 volt circuits to distribution panel using non-metallic sheathed cable.

TASK # 7.1.1 Rough in 120 or 240 volt circuits to distribution panel using non-metallic sheathed cable.

PERFORMANCE STANDARD: Cable(s) must be installed with sufficient length to reach point of connection. Cable(s) must enter panel through approved connectors. Circuits must be identified as to voltage or load served. Circuits must meet requirements as outlined by National Electrical Code (Article 336-5, 336-10) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit
Cable
Connectors
Distribution panel
Local code
National Electrical Code
Staples

PERFORMANCE STEPS:

1. Locate installation point.
2. Remove appropriate size knockout from distribution panel.
3. Attach a non-metallic connector to distribution panel.
4. Pull cable from the outside of distribution through the cable connector to opposite side of panel.
5. Tighten clamp on cable.
   NOTE: Be careful not to damage insulation.
6. Identify circuits as to load served.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of National Electrical Code.

3. Explain cable protrusion requirements.
4. Explain the different types of connectors and where they can and cannot be used.
5. Explain the possible results from damaging the insulation.
6. List and explain the various cable identification labels.
7. List and identify the load capacity of different cables.

LEARNING OUTCOME # 7.2 Rough in armored and non-metallic cable to outlet box.

TASK # 7.2.1 Rough in armored and non-metallic cable to outlet box.

PERFORMANCE STANDARD: Exposed cable must be supported at intervals not exceeding 4 1/2 feet and must be supported within 12 inches of box or fitting. Insulating bushing must be visible after installation. Cable must meet requirements as outlined by National Electrical Code (Article 333) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit	Local code
Bushing	National Electrical Code
Cable	Staples
Connectors	

PERFORMANCE STEPS:

1. Remove appropriate size knockout from outlet box.
2. Remove six inches of armor from cable end.
3. Attach armored cable connector to outlet box.
4. Install insulating bushing.
5. Feed wire through cable connector until cable bottoms out in connector.
6. Tighten connector on armored cable.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of the National Electrical Code.
3. Explain the function of insulating bushings.
4. Explain the difference between armored cable and non-metallic cable.
5. List examples where non-metallic cable cannot be used.
6. List disadvantages of armored cable.
7. List examples of where armored cable should be used.

LEARNING OUTCOME # 7.3 Rough in cable between an existing box and newly installed box.

TASK # 7.3.1 Rough in cable between an existing box and newly installed box.

PERFORMANCE STANDARD: Cable must be of sufficient amperage to serve connected load and must be suitable for location. Interior wall finish must not be damaged. Cable must meet requirements as outlined by National Electrical Code (Article 300, Part A) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit	Floor plans
Cable	Local code
Electric drill	National Electrical Code
Fasteners	

PERFORMANCE STEPS:

1. Turn power off.
2. Determine that power if off by checking conductor(s) at point of connection(s) with voltage tester.
3. Determine route for cable to travel.
4. Bore holes for cable as needed.

5. Remove knockout from both boxes.
6. Run cable.
   a. If armored cable, fasten cable to boxes with appropriate connector and install insulated bushing.
   b. If non-metallic cable, run cable into boxes and fasten cable to structure.
      NOTE: Be sure leave approximately six inches of freestanding wire in each box.
7. Turn power on.
8. Assure required operation.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of the National Electrical Code.
3. Explain how to route lines through the wall.
4. Explain cable size and box size requirements.
5. Read and interpret wiring schematic for existing power.

LEARNING OUTCOME:	7.4	Rough in cable or conduit for branch circuit
TASK #	7.4.1	Rough in cable or conduit for branch circuit.
PERFORMANCE STANDARD:		Installation must be completed without damaging interior finish. Cable or conduit must be of correct size for load to be served. Cable or conduit must extend from power source to outlet box of load served and must terminate in approved fittings. Branch circuits must meet requirements as outlined by National Electrical Code (Article 300, Part A, and Article 250) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit	Floor plans
Cables	Local code
Electric drill	National Electrical Code
Fasteners	

PERFORMANCE STEPS:

1. Determine location for installing the cable or conduit.
2. Remove knockout or provide opening for boxes.
3. Install cable connector or conduit connector.
4. Pull cable for circuit or run conduit for circuit.
5. Pull conductors through conduit as necessary.
6. Install insulated bushing for metallic conduit.
7. Attach cables or raceway to structure as required.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of National Electrical Code.
3. Read and interpret floor plans to determine cable routing requirements.
4. Explain cable size requirements.
5. Explain the load requirement for determining cable size.
6. Discuss cable size and box size restrictions.
7. List and identify the various types of fittings available.

LEARNING OUTCOME #	7.5	Rough in circuit for device controlled by two three-way switches with feed to switch box.
TASK #	7.5.1	Rough in circuit for device controlled by two three-way switches with feed to switch box.

PERFORMANCE STANDARD: Cable must be installed in most direct path. Power source must terminate at one of switch outlets. There must be sufficient conductors

in each box for circuit to function. Circuit must meet the requirements as outlined by National Electrical Code (Article 300, Part A) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit	Floor plans
Cable	Local code
Electric drill	National Electrical Code
Fasteners	

PERFORMANCE STEPS:

1. Locate previously installed boxes.
2. Run two-wire cable of appropriate size to device being controlled from remaining switch box.
3. Strip at least six inches of outer jacket from each cable.
4. Attach cable in outlet boxes using approved connectors.
5. Attach cable to building structure at required intervals.
6. Fold conductors back into box.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant section of the National Electrical Code.
3. Explain the internal design of three-way switches.
4. List and describe the types of cable required for three-way switches.
5. Explain the function of cable fasteners.
6. Demonstrate fastening cables.
7. Read and interpret floor plans to determine most direct route for cable.
8. Demonstrate stripping outer jackets.
9. List and describe situations where three-way switches are required.

LEARNING OUTCOME # 7.6 Rough in the circuit for device controlled by two three-way switches with feed to device outlet box.

TASK # 7.6.1 Rough in the circuit for device controlled by two three-way switches with feed to device outlet box.

PERFORMANCE STANDARD: Cable must be installed in most direct path. Power source must terminate at device outlet box. There must be sufficient conductors in each box for circuit to function. Circuit must meet requirements as outlined by National Electrical Code (Article 300, Part A) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit	Floor plan
Cable	Local code
Electric drill	National Electrical Code
Fasteners	

PERFORMANCE STEPS:

1. Locate previously installed boxes.
2. Run feeder cable of proper size into device outlet box.
3. Run three-wire cable of proper size from one switch box to device outlet box.
4. Run three-wire cable of proper size from other switch box to device outlet box.
5. Strip at least six inches of outer jacket from each cable.
6. Attach cable in outlet boxes using approved connectors.
7. Attach cable to building structure at required intervals.
8. Fold conductors back into box.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of the National Electrical Code.

3. Explain three-way switch internal design.
4. Explain type of cable required for three-way switches.
5. Explain cable fasteners.
6. Explain reading floor plan to determine most direct route for cable.
7. Explain stripping outer jacket.
8. Explain where three-way switches are required.
9. Discuss reasons for feeding to device box instead of switch box.

LEARNING OUTCOME # 7.7 Rough in circuit for device controlled by two three-way switches and one four-way switch.

TASK # 7.7.1 Rough in circuit for device controlled by two three-way switches and one four-way switch.

PERFORMANCE STANDARD: Cable must be installed in most direct path. Power source must terminate at three-way switch. There must be sufficient conductors in each box for circuit to function. Circuit must meet requirements as outlined by National Electrical Code (Article 300, Part A) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit	Floor plans
Cable	Local code
Electric drill	National Electrical Code
Fasteners	

PERFORMANCE STEPS:

1. Locate previously installed boxes.
2. Run feed or cable of proper size to one of three-way switch boxes.
3. Run three-wire cable from feed switch box to four-way switch box.
4. Run three-wire cable from four-way switch box to remaining three-way switch box.

5. Run two-wire cable from three-way switch box in step 4 to device being controlled.
6. Strip at least six inches of outer jacket from each cable.
7. Attach cable in outlet boxes using approved connectors.
8. Attach cable to building structure at required intervals.
9. Fold conductors back into box.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of the National Electrical Code.
3. Discuss where four-way switches are desirable.
4. Explain methods for fastening cables.
5. Explain reading floor plans to determine most direct route for cable.

LEARNING OUTCOME # 7.8 — Rough in circuit for device controlled by two three-way switches and one four-way switch with feed to device.

TASK # 7.8.1 — Rough in circuit for device controlled by two three-way switches and one four-way switch with feed to device.

PERFORMANCE STANDARD: Cable must be installed in most direct path. Power source must terminate at device outlet box. There must be sufficient conductors in each box for circuit to function. Circuit must meet requirements as outlined by National Electrical Code (Article 300, Part A) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit	Floor plans
Cable	Local code
Electric drill	National Electrical Code

Fasteners

PERFORMANCE STEPS:

1. Locate previously installed boxes.
2. Run feeder cable into device outlet box.
3. Run two-wire cable of proper size from device outlet box to one of three-way switches.
4. Run three-wire cable of proper size from one three-way switch box to four-way switch box.
5. Run three-wire cable of proper size from four-way switch box to other three-way switch box.
6. Strip at least six inches of outer jacket from each cable.
7. Attach cable in outlet boxes using approved connectors.
8. Attach cable to building structure at required intervals.
9. Fold conductors back into box.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of National Electrical Code.
3. Explain three-way switch internal design.
4. Explain four-way switch internal design.
5. Explain methods of fastening cables.
6. Explain reading floor plan to determine most direct route of cable.
7. Explain where four-way switches are required by code.
8. Explain stripping outer jacket.

LEARNING OUTCOME # 7.9 Rough in circuit for device controlled by two three-way switches and two four-way switches with feed to three-way switch.

TASK # 7.9.1 Rough in circuit for device controlled by two three-way switches and two four-way switches with feed to three-way switch.

PERFORMANCE STANDARD: Cable must be installed in most direct path. Power source must

terminate at one of three-way switches. There must be sufficient conductors in each box for circuit to function. Circuit must meet requirements as outlined by National Electrical Code (Article 300, Part A) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit	Floor plans
Cable	Local code
Electric drill	National Electrical Code
Fasteners	

PERFORMANCE STEPS:

1. Locate previously installed boxes.
2. Run feeder cable into three-way switch box.
3. Run three-wire cable of proper size from three-way switch box to four-way switch box.
4. Run three-wire cable of proper size from first four-way switch to second four-way switch box.
5. Run three-wire cable of proper size from second four-way switch box to second three-way switch box.
6. Run two-wire cable of proper size from device to second three-way switch box.
7. Strip at least six inches of outer jacket from each cable.
8. Attach cable in outlet boxes using approved connectors.
9. Attach cable to building structure at required intervals.
10. Fold conductors back into box.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of the National Electrical Code.
3. Explain internal design of three-way switch.
4. Explain internal design of four-way switches.
5. Explain methods of fastening cables.
6. Explain reading floor plans to determine most direct route for cable.
7. Explain stripping outer jacket.

8. List application where four-way switch system would be required and desirable.
9. Draw schematics for possible combination of four-way switch configurations.

LEARNING OUTCOME # 7.10 Rough in circuit for a door chime system.

TASK # 7.10.1 Rough in circuit for a door chime system.

PERFORMANCE STANDARD: Wire of correct size must be run from each door and transformer to point where chime system will be located. Sufficient length of wire must be left for future connection of door chime system. Transformer must be approved for location.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit	Fasteners
Cable and wire	Floor plans
Electric drill	

PERFORMANCE STEPS:

1. Locate installation point.
2. Install junction box and mount transformer.
3. Run feeder cable to junction box from power source.
4. Run door bell wire from transformer to chime unit.
5. Run wire from each push button location to chime unit location.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain function of transformer.
3. Discuss the principles of door chime operation.
4. Explain reading floor plan to determine location of transformer, chime unit, and controls.
5. List and explain the reasons for using low voltage to operate chimes and controls.

LEARNING OUTCOME # 7.11 Rough in line-voltage and low voltage thermostat wiring.

TASK(S) # 7.11.1 Rough in line-voltage thermostat wiring.

7.11.2 Rough in low voltage thermostat wiring.

TASK # 7.11.1 Rough in line-voltage thermostat wiring.

PERFORMANCE STANDARD: Wiring must have sufficient amperage to serve its intended purpose and must terminate in approved outlet box. Line-voltage thermostat wiring must meet requirements as outlined by National Electrical Code (Article 300, Part A) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit
Cable and boxes
Local code
Manufacturer's instructions
National Electrical Code

PERFORMANCE STEPS:

1. Run correct size cable from service panel to outlet box.
2. Attach cable to outlet box at thermostat location.
3. Pull cable from thermostat location to location of device being controlled.
4. Strip at least six inches of outer jacket from each cable.
5. Attach cable in outlet boxes using approved connectors.
6. Attach cable to building structure at required intervals.
7. Fold conductors back into box.

ENABLING OBJECTIVES:

1. Explain the relevant safety regulations and procedures.
2. Explain the relevant sections of National Electrical Code.
3. Describe operation of a line voltage thermostat.

4. List components of line voltage thermostat.
5. List advantages and disadvantages of line voltage thermostat.

LEARNING OUTCOME # 7.11 Rough in line-voltage and low voltage thermostat wiring.

TASK # 7.11.2 Rough in low voltage thermostat wiring.

PERFORMANCE STANDARD: Wiring must have sufficient number of conductors in cable to control device being served. Roughed in circuits for low-voltage thermostat wiring must meet requirements as outlined by National Electrical Code (Article 725, Part C) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit
Cable and boxes
Local code
Manufacturer's instructions
National Electrical Code

PERFORMANCE STEPS:

1. Read manufacturer's installation instructions.
2. Locate installation point of thermostat.
3. Run low-voltage wire from equipment to make up point of thermostat location.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of National Electrical Code.
3. Describe the operation of a low-voltage thermostat.
4. List the components of a low-voltage thermostat system.
5. List the advantages of a low-voltage thermostat.

LEARNING OUTCOME # 7.12 — Rough in duplex receptacle circuit with two three-way switches controlling one half of each of two duplex receptacles.

TASK # 7.12.1 — Rough in duplex receptacle circuit with two three-way switches controlling one half of each of two duplex receptacles.

PERFORMANCE STANDARD: Sufficient conductors must be installed at each box for circuit to function. Circuit must meet requirements as outlined by National Electrical Code (Article 300-14, 380, and 300-4) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit	Floor plans
Cables	Local code
Electric drill	National Electrical Code

PERFORMANCE STEPS:

1. Locate previously installed boxes.
2. Run power source into one three-way switch box.
3. Run three-wire cable of correct size between three-way switch boxes.
4. Run two-wire cable from other receptacle box to one three-way switch box.
5. Run wire cable between two receptacle boxes.
6. Strip at least six inches of outer jacket from each cable.
7. Attach cable in outlet boxes using approved connectors.
8. Attach cable to building structure at required intervals.
   CAUTION: TABS MUST BE REMOVED FROM DUPLEX RECEPTACLES.
9. Fold conductors back into box.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of National Electrical Code.

3. Describe the various split-wiring techniques.
4. Explain the advantages and disadvantages of split-wiring.
5. List the applications of split-wiring.

LEARNING OUTCOME # 7.13 Rough in cables for single pole switch controlling one or more lights or devices with feed to switch box and/or light device box.

TASK(S) #
- 7.13.1 Rough in cable for single switch controlling one or more lights or devices for feed to switch box.
- 7.13.2 Rough in cable for single pole switch controlling one or more lights or devices with feed to light device box.

TASK # 7.13.1 Rough in cable for single switch controlling one or more lights or devices for feed to switch box.

PERFORMANCE STANDARD: Six (6) inches of free wire must be left at each box. Rough in of cables must meet requirements as outlined by National Electrical Code (Article 300-4, 300-14, and 380) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit	Floor plans
Cable and boxes	Local code
Electric drill	National Electrical Code

PERFORMANCE STEPS:

1. Locate previously installed boxes.
2. Run cable from power source to box for switch.
3. Run cable from switch box to first light/device outlet box.
4. Run cable from first outlet box to second and succeeding outlet boxes if more than one light/device is to be controlled by this switch.
5. Strip at least six inches of outer jacket from

each cable.
6. Attach cable in outlet boxes using approved connectors.
7. Attach cable to building structure at required intervals.
8. Fold conductors back into box.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of National Electrical Code.
3. Explain how to calculate size and type of cable needed for installation called for on floor plans.
4. Identify how the electricity will flow through the circuit.
5. Differentiate between single pole switches, three-way switches, and four-way switches.
6. Explain how to read floor plan to locate components and calculate most direct route for the cable.
7. Identify the type of box connectors to be used for the job.
8. Calculate the size of boxes required for the installation specified.

TASK # 7.13.2 Rough in cables for single pole switch controlling one or more lights or devices with feed to light device box.

PERFORMANCE STANDARD: Six (6) inches of free wire must be left at each box. Cables must meet requirements as outlined by National Electrical Code (Article 300-4, 300-14, 380, and 336-5) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit	Floor plan
Cable and boxes	Local code
Electric drill	National Electrical Code

PERFORMANCE STEPS:

1. Locate previously installed boxes.
2. Run feeder cable from power source to first light/device box.

3. Run cable from first light/device box to box at switch location.
4. Extend cable from first light/device box to second and succeeding outlet boxes if more than one light/device is to be controlled by this switch.
5. Strip at least six inches of outer jacket from each cable.
6. Attach cable in outlet boxes using approved connectors.
7. Attach cable to building structure at required intervals.
8. Fold conductors back into box.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of National Electrical Code.
3. Explain switch loop circuits.
4. Explain how to calculate size and type of cable.
5. Identify how the electricity will flow through the circuit.
6. Differentiate between single-pole, three-way, and four-way switches.
7. Identify the types of box connector to be used for the job.

LEARNING OUTCOME #	7.14	Rough in circuit for single pole switch controlling three lights or device with feed to end light device box.
TASK #	7.14.1	Rough in circuit for single pole switch controlling three lights or device with feed to end light device box.
PERFORMANCE STANDARD:		Cable must extend from power source to last light or device box. Cable must be of required size and type for load being served. At least six inches of free conductors must be left at each outlet box and switch boxes. Circuit must meet requirements as outlined by

National Electrical Code (Article 300-4, 300-14, 380, 336-5) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit	Floor plans
Cable	Installed boxes
Drill	Local code
Fasteners	National Electrical Code

PERFORMANCE STEPS:

1. Locate previously installed outlet boxes.
2. Run feed cable from the power source to last light/fixture device box.
3. Run three-wire cable from one light device box to second light box.
4. Repeat step 3 until all light or device boxes are connected together with three-wire cable.
5. Run two-wire cable to switch box from last light or device in series.
6. Strip at least six inches of outer jacket from each cable.
7. Attach cable in outlet boxes using approved connectors.
8. Attach cable to building structure at required intervals.
9. Fold conductors back into box.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of the National Electrical Code.
3. Explain how to secure cable to boxes.
4. Explain reading floor plans for location of switches and devices with the most direct route for cable.
5. Demonstrate stripping cable.

LEARNING OUTCOME # 7.15 Rough in circuit for split circuit duplex receptacle.

TASK # 7.15.1 Rough in circuit for split circuit duplex receptacle.

PERFORMANCE STANDARD: Roughed in circuit for split circuit duplex receptacle must meet requirements as outlined by National Electrical Code (Article 210-4, 210-6, Subsection C, 1 and 2) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit	Floor plans
Cables	Installed boxes
Drill	Local code
Fasteners	National Electrical Code

PERFORMANCE STEPS:

1. Locate previously installed wall box.
2. Run three-wire cable from the power source to wall box.
3. Strip at least six (6) inches of outer jacket from each cable.
4. Attach cable in outlet boxes using approved connectors.
5. Attach cable to building structure at required intervals.
6. Fold conductors back into box.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of the National Electrical Code.
3. Explain how to read floor plan to determine most direct route for cable.
4. Demonstrate cable fastening techniques.
5. List the various types of cables and their uses.
6. Explain advantages and disadvantages of split-wiring.
7. Discuss the reasons for stripping cable.

LEARNING OUTCOME # 7.16 Measure, cut, and bend conduit.

TASK # 7.16.1 Measure, cut, and bend conduit.

PERFORMANCE STANDARD: Conduit must be cut to specified length. Sharp edges must be filed clean. All bends must be even so as not to bind or damage wire.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit
Conduit bender
Schematic or drawing

PERFORMANCE STEPS:

1. Locate installation points.
2. Measure length required.
3. Measure and mark conduit.
4. Cut conduit.
5. Mark area to be bent.
6. Bend with bender.
7. Check fit.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain how to calculate lengths for bends.
3. Demonstrate tools and techniques for cutting conduit.
4. Demonstrate technique for conduit bender.

LEARNING OUTCOME # 7.17 Make joints using crimp-type connectors.

TASK # 7.17.1 Make joints using crimp-type connectors.

PERFORMANCE STANDARD: Joint must be made using appropriate tool to assure required mechanical strength. Insulation applied to joint must be equivalent to insulation rating of conductor. Connecting device must be approved for application. Joint must meet requirements as outlined by National Electrical Code (Article 110-14) and local

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit	Local code
Cable	National Electrical Code
Connector	

PERFORMANCE STEPS:

1. Remove approximately 3/4's inch of insulation from each conductor.
2. Group conductors together and insert wires into connector.
3. Apply pressure to make connection using correct crimp tool.
4. Remove crimp tool.
5. Cut off excess wire outside crimp.
6. Check each conductor by pulling on it to be sure joint is mechanically strong.
7. Tape or otherwise insulate connection to withstand applied voltage.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of the National Electrical Code.
3. Identify the different types of crimp connectors.
4. Describe where crimp connectors can be used.
5. Describe how you test a crimp connection.
6. Explain the advantages of a crimp connector.
7. Discuss the techniques and requirements for stripping insulation.
8. Differentiate between electrical and mechanical connection.

LEARNING OUTCOME # 7.18 Make pigtail splice.

TASK # 7.18.1 Make pigtail splice.

PERFORMANCE STANDARD: Splice must be mechanically strong and insulated electrically to withstand applied voltage. Splice must meet requirements as outlined by National Electrical Code (Article 110-14) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit
Cable/wire
Local code
National Electrical Code

PERFORMANCE STEPS:

1. Remove approximately one inch of insulation from each conductor.
2. Cross ends.
3. Hold wires together and twist for 6 or 8 turns.
4. Double ends back with pliers so that insulation will not be punctured.
5. Solder tip of splice.
6. Insulate wire with approved means.
7. Tape or otherwise insulate connection to withstand applied voltage.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of the National Electrical Code.
3. Identify where a pigtail splice can be used.
4. Define the term mechanical strength for a connection.
5. Demonstrate techniques.
6. Differentiate between rosin and acid type fluxes.
7. Explain stripping of insulation.

LEARNING OUTCOME # 7.19 Make splices using mechanical-type connectors.

TASK # 7.19.1 Make splices using mechanical-type connectors.

PERFORMANCE STANDARD: Splice(s) must be made to assure mechanical strength. Splice(s) must be insulated to withstand applied voltage. Splice(s) must meet requirements as outlined by National Electrical Code (Article 110-14) and local authority having

PERFORMANCE STEPS:

1. Remove 1/2" to 3/4" insulation from each conductor to be joined.
2. Select appropriate connectors for connection(s) to be made.
3. Group conductors together and insert wires into connectors.
4. Tighten connector on conductors.
5. Check each conductor by pulling on it to be sure joint is mechanically strong.
6. Tape or otherwise insulate connection to withstand applied voltage.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of the National Electrical Code.
3. Describe how to check mechanical strength.
4. Differentiate between a good insulated connection and a poor insulated connection.
5. List advantages of mechanical connector.
6. Describe the types of tapes that can be utilized and the wrapping requirements.

LEARNING OUTCOME # 7.20 Rough in a single pole switch circuit.

TASK # 7.20.1 Rough in a single pole switch circuit.

PERFORMANCE STANDARD: Six (6) inches of free wire must be left at each box for future connections and splices. Circuit must meet requirements as outlined by National Electrical Code (Article 300, Part A) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit
Cable
Electric drill
Floor plans
Local code
National Electrical Code
Roughed in boxes

PERFORMANCE STEPS:

1. Locate previously installed box.
2. Run cable as follows:
   a. <u>If power source is to terminate at light switch:</u>
      (1) Run cable of correct size and type from power source to device switch location.
      (2) Run cable of correct size and type from switch location to device outlet box.
   b. <u>If power source is to terminate in fixture/ device box:</u>
      (1) Run cable of correct size and type from power source to device outlet box.
      (2) Run cable of correct size and type from device outlet box to switch location.
3. Strip at least six inches of outer jacket from each cable.
4. Attach cable in outlet boxes using approved connector.
5. Attach cable to building structure at required intervals.
6. Fold conductors back into boxes.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of the National Electrical Code.
3. Locate on floor plan boxes and determine the most direct route for cable.
4. Identify from the floor plan the correct type and size of cable to be installed.
5. Identify the type of connectors to be used.
6. Describe code requirements for cable being secured to the structure.
7. Differentiate between a wire connector and a box connector.

LEARNING OUTCOME #	7.21	Run feeder cable from main service panel to auxiliary panel.
TASK #	7.21.1	Run feeder cable from main service panel to auxiliary panel.

PERFORMANCE STANDARD: Sufficient cable must be left at each panel for connections. Cable must be run in most direct route between panels. Cables must be attached to panel boxes with approved connectors. Feeder cable must meet requirements as outlined by National Electrical Code (Article 300 and 384) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit	Local code
Cable	National Electrical Code
Drill	Roughed in auxiliary panel
Floor plans	Roughed in main panel

PERFORMANCE STEPS:

1. Locate installation point.
2. Remove knockouts from panel boxes.
3. Install cable connector to each panel box.
4. Strip sufficient outer jackets from each cable ends.
5. Attach cable to each panel using approved connectors.
6. Attach cable to building structure at required intervals.
7. Fold conductors into panel boxes.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of the National Electrical Code.
3. Differentiate between a main service panel and an auxiliary service panel.
4. Identify the conditions where auxiliary panels are desirable.
5. Describe how to strip outer jacket of cable.
6. Explain how to calculate for size of cable to be run between the panels.

UNIT #8 Trim Out

LEARNING OUTCOME # 8.1 Connect door chime system.

TASK # 8.1.1 Connect door chime system.

PERFORMANCE STANDARD: Button at each location must cause chime to operate. Connecting of door chime system must meet requirements as outlined by National Electrical Code (Article 725) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit	National Electrical Code
Connector	Roughed in box
Floor plans	Roughed in cable
Local code	Voltage tester
Manufacturer's installation instructions	

PERFORMANCE STEPS:

1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Attach chime unit to structure.
6. Make low-voltage wiring connections.
7. Assure door chime operation.
   a. Repeat steps 4-6 until door chime is operational.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of the National Electrical Code.
3. Read and interpret floor plan for location of components.
4. Describe how door chime circuit operates.
5. List component parts of door chime system.
6. Describe how to test door chime system.

LEARNING OUTCOME # 8.2 Install duplex receptacle outlets.

TASK # 8.2.1 Install duplex receptacle outlets.

PERFORMANCE STANDARD: Connections must be made using methods and connectors suitable for purpose. Finished outlets must have correct polarity. Cover plate must be straight, cover opening, and fit flush to wall. All receptacles must be mounted in manner to present uniform appearance. Duplex receptacle outlets must meet requirements as outlined by National Electrical Code (Article 200-10, Article 200-11) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit	National Electrical Code
Connectors	Receptacles
Floor plans	Roughed in boxes
Local code	Roughed in cables

PERFORMANCE STEPS:

1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at point of connection(s) with voltage tester.
4. Cut conductor at wall box to leave six (6) inches of free conductor.
5. Remove approximately 3/4's inch of insulation from each conductor.
6. Connect white conductors to silver or white terminals.
7. Connect black conductor to brass or gold colored terminals.
   a. If there are two or more grounding conductors, they must be securely connected together using approved means and fastened to receptacle and to box if required.
   b. If box is metal, connect grounding conductors to green terminals and to wall box.
8. Fasten outlet to wall box.
9. Install cover plate.
10. Turn power on.
11. Test for correct polarity.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of the National Electrical Code.
3. Identify the color code and terminal code connections.
4. Describe the correct polarity requirements of the code.
5. Demonstrate how to connect and read a voltage tester.
6. Describe how to strip insulation.
7. Describe overload protection procedures.
8. Describe the operation of split circuits.

LEARNING OUTCOME # 8.3 Install four-wire 220 volt receptacles.

TASK # 8.3.1 Install four-wire 220 volt receptacles.

PERFORMANCE STANDARD: Connections must be made using materials and conductors suitable for conditions encountered. Receptacle must be supplied with correct voltage and must have required polarity. Installation must meet requirements as outlined by National Electrical Code and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit	National Electrical Code
Connectors	Receptacles
Floor plans	Roughed in boxes
Local code	Roughed in cable
Manufacturer's installation instructions	Voltage tester

PERFORMANCE STEPS:

1. Locate installation point.

2. Turn power off.
3. Determine that power is off by checking conductor(s) at point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Cut conductors at wall box to leave six (6) inches of free conductor.
6. Remove approximately 3/4's inch insulation from each conductor.
7. Connect grounding conductor (green or bare) to grounding terminal.
8. Connect one-line conductor to one of brass or gold colored terminal.
9. Connect remaining line conductor.
10. Connect white conductor to identified neutral terminal.
11. Attach receptacle to wall box.
12. Install cover plate.
13. Turn power on.
14. Check for required polarity.
15. Check for required voltage.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of the National Electrical Code.
3. Describe the type of connectors that can be utilized.
4. Identify the color code requirements for the cable.
5. Differentiate between the ground and the neutral system.
6. Describe how to test for correct polarity.
7. Explain the procedures for insuring overload protection.

LEARNING OUTCOME # 8.4 Install ground fault interrupting device.

TASK # 8.4.1 Install ground fault interrupting device.

PERFORMANCE STANDARD: Ground fault interrupting device must be installed according to manufacturer's instructions. Ground fault interrupting device must function to open circuit when

tested as per manufacturer's instructions. Installation/connection of ground fault interrupting device must meet requirements as outlined by National Electrical Code (Article 210, Section 8, and Article 680) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit	Manufacturer's installation instructions
Connectors	National Electrical Code
Floor plans	Roughed in boxes
Ground fault device	Roughed in cables
Local code	

PERFORMANCE STEPS:

1. Locate installation point.
2. Turn power off.
3. Determine that power if off by checking conductor(s) at point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Snap or bolt breaker in breaker panel if circuit breaker-type device.
6. Locate circuit conductors to be protected for ground fault interrupting device.
7. Remove approximately 3/4's inch insulation from each conductor.
8. Connect grounding conductor to ground bar in breaker panel.
9. Connect white or neutral conductor to identified terminal of circuit breaker.
10. Connect free end of coiled white neutral conductor of lead attached to circuit breaker to neutral bar in breaker panel.
11. Connect black or circuit conductor to load terminal of circuit breaker.
12. Determine outlet box for mounting if ground fault interrupting is of ground fault interrupting receptacle type.
    a. Fold wire ends out of wall box.
    b. Remove approximately 3/4's inch insulation from each conductor.
    c. Connect green or bare conductor to grounding terminal and to wall box if it is metal.
    d. Connect white wire to silver colored terminal of receptacle.
    e. Connect black wire to brass colored terminal of receptacle.

f. Attach ground fault interrupting device to wall box.
g. Attach cover plate.

13. Turn power on.
14. Test units for correct operation as per manufacturer's instructions.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of the National Electrical Code.
3. List where ground fault systems are required by National Electrical Code.
4. Describe how a ground fault interrupter system functions.
5. Differentiate between a ground fault interrupter breaker and a ground fault interrupter outlet.
6. Describe how to test ground fault interrupter.
7. Explain importance of correct polarity.

LEARNING OUTCOME # 8.5 Install hot water heater.

TASK # 8.5.1 Install hot water heater.

PERFORMANCE STANDARD: Heater must be supplied with required voltage. Heater must be grounded and connections must be tight and insulated. Installation/connection of water heater must meet requirements as outlined by National Electrical Code (Article 422, Section 14) and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit	Manufacturer's installation instructions
Connectors	National Electrical Code
Floor plans	Roughed in boxes
Hot water heater	Roughed in cable
Local code	

PERFORMANCE STEPS:

1. Locate installation point.

2. Turn power off.
3. Determine that power is off by checking conductor(s) at point of connection(s) with voltage tester.
4. Install cable connector or conduit connector in junction box on water heater.
5. Connect cable or conduit to water heater.
6. Remove approximately 3/4' inch insulation from each conductor.
7. Connect wiring using method and materials suitable for conditions encountered.
8. Read water heater nameplate.
9. Determine that correct voltage is available at water heater.
10. Check to see that tank is full of water.
11. Turn power on.
12. Check power consumption using clamp on ampmeter.
13. Install cover plate.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of the National Electrical Code.
3. Describe how a hot water heater functions.
4. List the components of a hot water heater system.
5. Identify the correct polarity for wiring.
6. Demonstrate how to connect and read an ammeter.
7. Describe how to strip conductors and the type of connectors that should be used for water heat connection.

LEARNING OUTCOME #	8.6	Connect low-voltage lighting control.
TASK #	8.6.1	Connect low-voltage lighting control.
PERFORMANCE STANDARD:		Connections must be made using method and connectors required by manufacturer and National Electrical Code and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit	Manufacturer's installation instructions
Connectors	National Electrical Code
Floor plans	Roughed in boxes
Local code	Roughed in cable
Low-voltage control unit	

PERFORMANCE STEPS:

1. Locate installation point.
2. Turn power off.
3. Determine that power if off by checking conductor(s) at point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Connect power leads of low-voltage control devices to light fixture wiring using suitable connectors.
6. Connect low-voltage control lead to relays and switches as required to complete wiring of low-voltage lighting control using suitable connector.
7. Turn power on.
8. Check for operation of control system.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of the National Electrical Code.
3. Identify and describe the applications for low-voltage lighting controls.
4. Explain the operation of a low-voltage lighting control system.
5. List and describe the components of a low-voltage control system.
6. Identify how a relay functions.
7. Locate from the floor plan the locations of the components of a low-voltage lighting control.

LEARNING OUTCOME # 8.7 Install photo-electric cell control.

TASK# 8.7.1 Install photo-electric cell

control.

PERFORMANCE STANDARD: Connections must be made using method and connectors required by manufacturer and National Electrical Code and local authority having jurisdiction. Connections must be tight. Device must be tested to assure required operation.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

- Standard tool kit
- Connectors
- Floor plans
- Local code
- Manufacturer's installation instructions
- National Electrical Code
- Photo-electric cell control
- Roughed in boxes
- Roughed in cables
- Voltage tester

PERFORMANCE STEPS:

1. Locate installation point.
2. Turn power off.
3. Determine that power if off by checking conductor(s) at point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Attach photo-electric cell to outlet box or light fixture as appropriate.
6. Make wiring connections per manufacturer's instruction using suitable connectors.
7. Install cover plates or rehang fixture.
8. Turn power on.
9. Assure required operation.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of the National Electrical Code.
3. Describe how a photo-electric device functions.
4. Identify the parts of a photo-electric cell control.
5. Explain how to test photo-electric cell control.
6. List the applications for photo-electric cell controls.

LEARNING OUTCOME # 8.8 Connect recessed fixture box in ceiling.

TASK # 8.8.1 Connect recessed fixture box in ceiling.

PERFORMANCE STANDARD: Connections must be made using methods and connectors required by manufacturer and National Electrical Code and local authority having jurisdiction. Polarity must be correct and fixture must be grounded.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit	National Electrical Code
Connectors	Recessed fixture
Floor plans	Roughed in box
Local code	Roughed in cable

PERFORMANCE STEPS:

1. Locate previously installed box.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at point of connection(s) with voltage tester.
4. Remove approximately 3/4's inch insulation from end of each conductor.
5. Make wiring connections n junction box, using correct connectors and methods and observing correct polarities.
6. Insulate all connections.
7. Fold wiring back into junction box.
8. Install cover on junction plate.
9. Install lamp no greater than manufacturer's recommendation.
10. Install fixture trim.
11. Turn power on.
12. Assure required operation.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of the National Electrical Code.
3. Describe the wiring methods used for recessed fixture.
4. Explain the operation of recessed fixtures.

5. Describe the clearance requirement for a recessed fixture.
6. Identify on the floor plan the location of the recessed fixture.
7. List advantages and applications of recessed fixtures.

LEARNING OUTCOME # 8.9 Connect single pole switch with and without pilot light.

TASK # 8.9.1 Connect single pole switch with and without pilot light.

PERFORMANCE STANDARD: Switch must control intended device. Pilot light must indicate when switch is in position, if so equipped. Connection must meet National Electrical Code requirements and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

- Standard tool kit
- Connectors
- Floor plans
- Local code
- Manufacturer's installation instructions
- National Electrical Code
- Roughed in boxes
- Roughed in cables
- Switches

PERFORMANCE STEPS:

1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Cut conductor at wall box to leave six (6) inches of free conductor.
6. Remove approximately 3/4's inch insulation from conductor.
7. Connect white or neutral conductor to white or silver terminal on pilot light.
8. Connect ungrounded conductors to identified line of lead conductors of switch.

9. Attach switch with pilot light to wall box.
10. Install cover plate.
11. Turn power on.
12. Turn switch on.
13. Assure required operation.
14. Re-check connections if device does not work or pilot light does not burn.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of the National Electrical Code.
3. Identify and describe the use of wire, cable boxes, fixtures, and single pole switches.
4. Describe the condition where a pilot light switch would be desirable.
5. Describe the two types of pilot light switches.

LEARNING OUTCOME # 8.10 Connect split circuit duplex receptacles.

TASK # 8.10.1 Connect split circuit duplex receptacles.

PERFORMANCE STANDARD: Finished wiring must be supplied from two sources. Cover must be installed flush with wall, level across top, and cover opening in wall. Polarity must be correct. Connection must meet National Electrical Code requirements and local authority having jurisdiction.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

- Standard tool kit
- Connectors
- Floor plans
- Local code
- Manufacturer's installation instructions
- National Electrical Code
- Receptacles
- Roughed in boxes
- Roughed in wiring
- Voltage tester

PERFORMANCE STEPS:

1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Cut conductor at wall box to leave six (6) inches of free conductor.
6. Remove approximately 3/4's inch insulation from each conductor.
7. Remove break-off tab from line side of receptacle to cause it to be split-wired receptacle.
8. Connect white or neutral conductor to silver or white terminal.
9. Connect one of supply conductor to one brass or gold terminals.
10. Connect remaining supply conductor to remaining brass or gold terminal.
11. Connect bare or green grounding conductor to green terminal and to wall box if it is metal box.
12. Attach duplex receptacle to wall box.
13. Install cover plate.
14. Turn power on.
15. Check that receptacle has been supplied from two sources by turning off one source.
16. Test for correct polarity.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of the National Electrical Code.
3. Explain the operation of a split circuit receptacle.
4. Describe the wiring methods used for split circuit duplex receptacle circuits.
5. Identify where split circuit receptacles could be utilized.
6. Explain the advantages and disadvantages of split circuit systems.
7. Define correct polarity requirements for split circuit systems.

LEARNING OUTCOME # 8.11 Connect three-wire 220 volt receptacle.

TASK # 8.11.1 Connect three-wire 220 volt receptacle.

PERFORMANCE STANDARD: Connections must be made using materials and conductors required by manufacturer and National Electrical Code, and local code having authority. Receptacle must be supplied with correct voltage and must have correct polarity.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit	National Electrical Code
Connectors	Roughed in box
Floor plans	Roughed in wiring
Manufacturer's installation instructions	Voltage tester
	220 receptacle

PERFORMANCE STEPS:

1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Determine that power has been turned off by checking each conductor with a voltage tester.
6. Cut conductor at wall box to leave six (6) inches of free conductor.
7. Remove approximately 3/4's inch insulation from each conductor.
8. Connect grounding conductor (green or bare) to grounding terminal.
9. Connect one-line conductor to one of brass or gold colored terminal.
10. Connect remaining line conductor to other brass or gold colored terminal.
11. Attach receptacle to wall box.
12. Install cover plate.
13. Turn power on.
14. Check for correct polarity and voltage.

ENABLING OBJECTIVES

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of the National Electrical Code.
3. Explain the operational characteristics of 220 volt AC circuits.
4. Explain the procedures for insuring overload protection.
5. Describe the applications for special purpose receptacles.
6. Describe the wiring methods required for special purpose receptacle outlet circuits.

ELECTRICAL OCCUPATIONS/RESIDENTIAL ELECTRICITY
STANDARD TOOL KIT

Allen wrench set, large
Awl, metal
Bolt cutter, small
Chisel, wood
Crimper, terminal
Drill, 1/2" electric
Drill, 3/4" or 1" electric
File, rattail
Folding rule
Hack saw
Hammer, claw
Hat, hard
Hole, saw set
Knife, electrician
Level - torpedo (pocket) 8"
Local code book (current issue)
Multi-meter - volt ohm, rmp's
National Electrical Code Book (current issue)
Nut driver
Pliers - slip joint 10"
Pliers, diagonal
Pliers, lineman
Pliers, needle-nose
Puller, fuse
Rule, folding
Screwdriver, flat - 4", 6", 8", 12" - plastic handle
Screwdriver, Phillips - 4" and 6"
Tape measure
Tool pouch and belt
Wire strippers
Wrench, adjustable 8" and 2-16" pipe